PROC. BIOL. SOC. WASH.
106(4), 1993, pp. 740–748

ACTIVITY AND REPRODUCTIVE PATTERNS OF AMPHIBIANS AND REPTILES FROM THE ENGARE ONDARE RIVER REGION OF CENTRAL KENYA, DURING THE DRY SEASON

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Abstract.—This is the first report of the reproductive patterns and activities of a sample of frogs and lizards from the remote region of Isiolo District in central Kenya during the dry season. Seventeen species were active and feeding; one species was dormant and not feeding. Five species were reproductive and thirteen species were clearly not reproductive. Adaptive partitioning of the reproductive cycle of some species seems to be occurring.

There are no reports on the herpetofauna of the remote region of Isiolo District in central Kenya nor is there any information concerning the activity, reproduction, and relative abundance of reptiles and amphibians during the summer dry season in this arid habitat. Western (1974) studied lizards for 17 days near Lokori in South Turkana, Kenya. That area is 235 km NW of our site and separated from it by the Suguta Valley (300–400 m) and the Lerochi Plateau (2000–2600 m). Even though taxonomic literature for amphibians and reptiles in Kenya is abundant, few papers give reproductive and feeding data, especially during the dry season.

Hebrard (1980) reported on the habitats of *Chamaeleo* during the dry season in localities south of Nairobi. Greer (1967) studied comparative ecology of two species of *Lygodactylus* in northwestern Kenya during the dry season. The report by Loveridge (1929) does not present reproductive nor activity data and includes only a few records in central Kenya. Western (1974) reported biomass data for lizards but did not include reproductive or feeding data. Other reports concerned only the rainy season (Bogert 1942) or only the rain forest (Loveridge 1935, 1936; Drewes 1976). This paper concerns some species of frogs and lizards from Isiolo District, Eastern Province, of central Kenya during the middle of the dry season (July 1987).

It is of interest to know which species are reproductive and feeding during the dry season, which species are active but not reproductive (are they feeding?), and which are dormant. Until we know how each species responds to seasonal change, we cannot differentiate populational changes that might be due to natural biological interactions from those resulting from the ever-increasing impacts from over-grazing by domestic animals. The objectives are to identify 1) those species of amphibians and reptiles that are actively feeding versus those that are dormant and 2) those that are reproductive versus those that are not reproductive.

Hardy and John L. Darling arrived on 11 July 1987 and departed on 3 August 1987. The camp was 20.6 km west and 1.5 km south of Isiolo, Isiolo District, at an elevation of 1120–1140 m, on the eastern bank of the Engare Ondare River, which forms the boundary between Isiolo and Laikipia Districts (Fig. 1). During that period no rain fell and the camp workers reported that the

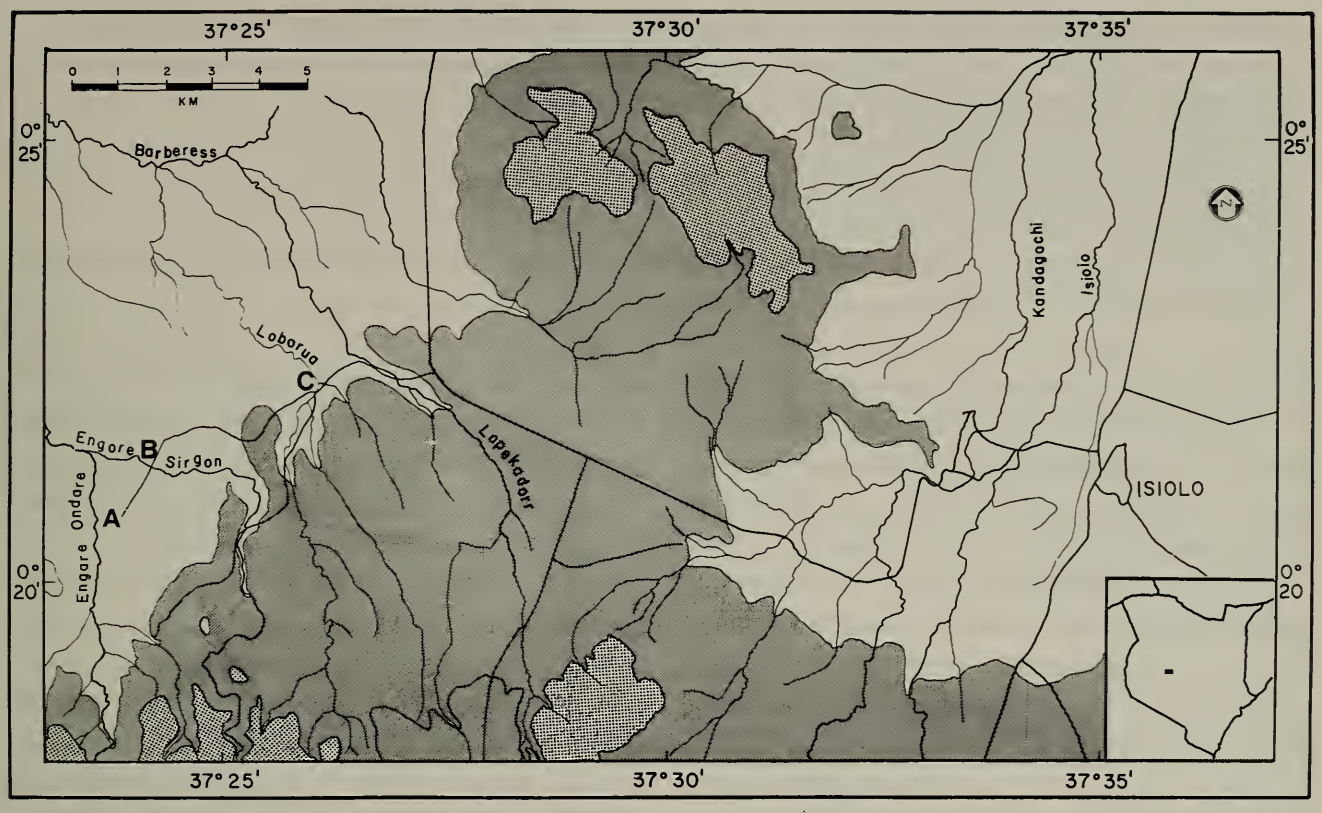

Fig. 1. Map showing vicinity of Isiolo, Isiolo District, Eastern Province, Kenya. Uppercase letters identify collection locations (Table 1). Heavy stipling represents area above 1400 m; fine stipling represents areas between 1200 and 1400 m elevation.

last rain was in March or April and none was expected until October. The annual rainfall in this general region of Kenya is 50–100 cm.

The Engare Ondare is a permanent stream near our camp; however, as the dry season progressed the stream dried from the northern lower end toward the mountains to the south. During our stay, the lower end of the stream advanced (by drying) to within 2–3 km north of camp. At our location the stream was 1–3 m wide, 10–20 cm deep, and flowing over a rocky or compacted mud substrate. The flood channel of the stream was 10–50 m wide with sandy, eroded banks up to 10 m high; the floor and sides were composed of sand with mixed gravel and rocks.

Acacia trees, up to 10 m high, were abundant and formed a riparian buffer between the stream and the surrounding desert. Among the *Acacia* were several shrubs, including *Euphorbia,* sparse grass, and a variety of perennials and annuals. The *Acacia* forest was 50–100 m wide on each side of the river. Beyond the *Acacia* forest, the desert was a short thorn forest consisting of several species of sparse *Acacia* (2–3 m high), *Euphorbia,* and small-leafed perennial shrubs. Abundant grass (not *Cynodon*) was found only at distances of 1–2 km from the river and away from areas grazed by goats; *Cynodon* was in small clumps on the river bank and in a wet meadow.

Methods

All preserved specimens are in the Museum of Life Sciences of Louisiana State University in Shreveport (LSUS). Collection localities (A–E) are defined in Table 1.

One testis and the largest ovum were measured to 0.01 mm with dial calipers under a dissecting microscope. In frogs, oviducal eggs or amplexus was interpreted as an accurate indication of relatively immediate reproduction and oviposition. Enlarged ovarian eggs could occur over a long

Table 1.—Collection localities. Letters A–E are used in the text to identify the following localities.

A) Isiolo Dist.: 20.6 km W, 1.5 km S Isiolo.
B) Isiolo Dist.: 20.0 km W, 0.4 km S Isiolo.
C) Isiolo Dist.: 16.6 km W, 1.2 km N Isiolo.
D) Isiolo Dist.: Jct. Kenya hwy. A2 & Ewaso Ngiro.[a]
E) Laikipia Dist.: 1–2 km E 0l Doinyo Lossos peak.[a]

[a] Locality not shown in Fig. 1.

period of time and would not always indicate immediate reproduction. Calling of anurans and enlarged seminiferous tubules and vas deferentia indicate a non-dormant condition, probably feeding, but not necessarily immediately reproductive (the females may not yet be receptive). The presence of recognizable food items in the stomach was used as an indication of relatively recent (probably within 24 hours) feeding activity. All measurements are in mm. Sexes are combined for statistics of small samples.

Results

Bufo garmani Meek.—(LSUS 4776, locality A; 4777, B; 4778–4809, A; 4865, A; total $n = 35$). SVL was 53–74 ($\bar{X} = 66.0$, $n = 22$) in males and 62–89 ($\bar{X} = 72.4$, $n = 12$) in females. Testes were 0.8–2.1 ($\bar{X} = 1.6$) × 9.1–16.1 ($\bar{X} = 11.9$). Four females with SVL < 66 had non-pigmented ova (0.4 diameter or less) and eight with SVL > 68 had pigmented ova (0.7 dia. or greater). The two specimens (4781, 4808) with the largest ova (1.4 dia.) had ovulated (oviducal eggs) and were 80 and 83 SVL. One metamorph (4865), 11.3 SVL with a regressing tail 3.1 long, was found under a rock in wet sand on 29 July at 1605–1650 h. The sex ratio of the 34 adults (SVL > 52) was 1 female to 1.8 males. All specimens lacked bright scarlet on the posterior surface of the thigh and dark spots on the dorsum of the snout, thus eliminating *B. regularis* and had reniform paratoids, not like *B. kerinyagae* (Keith 1968). All specimens except two (6%; one male and one female) had food in the stomachs. Two specimens (LSUS 4776 on 12 July, 4792 at 0950 h on 19 July) were flushed from holes in sandy soil by flooding with a bucket of water. Another (LSUS 4777) was found under a log in a grassy meadow (1100 h) on 14 July. A pair in amplexus (LSUS 4780–81) was found along the river at 2200–2400 h, 14 July. One male was calling from within a burrow at the base of the arroyo bank well away from the water; it was dug out at 1920 h (14 July). All other specimens were found along the edge of the water in sandy areas; none was found in the thick Bermuda grass (*Cynodon*) that grows in small patches along the river.

Tomopterna cryptotis (Boulenger).—(LSUS 4810–11, A). Two males were found on wet sand along the edge of the river (LSUS 4810 on 14 July; LSUS 4811 at 1930–2100 h, 25 July); neither was calling nor moving. Testes were 0.5 × 2.4 and 1.0 × 4.5 respectively. One stomach contained insects; the other was empty.

Hemisus marmoratum (Peters).—(LSUS 4876; A). A male (SVL = 32; testis spherical, 1.7 dia.) with an empty stomach was dug from moist sandy loam, at a depth of 15–16 cm, in a sand bar next to the river (0900 h on 26 July). Because of its empty stomach, small gonads, depth at which it was buried, and clean appearance (as if it were in a chamber, rather than embedded in sand) we assumed that it was dormant. No eggs were found.

Ptychadena anchietae (Bocage).—(LSUS 4813–26, A; 4827–30, B; 4831–60, A; 4861–64, D; total $n = 52$). Males had SVLs of 27–40 ($\bar{X} = 35.5$; $n = 21$); females 18–55 ($\bar{X} = 37.5$; $n = 30$). All males 35 SVL or larger

had testes greater than 1.0 × 2.7 (max. size = 1.4 × 4.1); those with smaller testes were less than 34 SVL. Some females 35 SVL or greater had enlarging oocytes (greater than 0.1 dia.), other specimens from 18 to 45 SVL did not contain enlarged oocytes. All females larger than 48 SVL had pigmented oocytes up to 1.3 diameter (probably ready for ovulation), but none had ovulated. Even though some males were calling, this species was probably not reproducing at that time; none of the females had ovulated. Food was present in the stomachs of 48 specimens; two females and two males had empty stomachs. The male with the largest testis had an empty stomach. In life, most specimens were yellow postero-ventrally with yellowish-green stripes on the posterior surface of the thigh; some had a green mid-dorsal stripe. All were found near the water; some in the water, along the stream margin on sand, others in the thick bermuda grass (*Cynodon*) on the bank.

Ptychadena mascareniensis (Dumeril and Bibron).—(LSUS 4867–73, A). SVL $\bar{X}$ = 43.9, range = 28–55, n = 7. The smallest individual was a non-reproductive female (SVL = 28); all others (SVL > 41) were reproductive. Three mature females contained enlarged ovarian ova and one contained oviductal eggs. Two males had testes measuring 4.7 × 1.3 and 3.9 × 1.3 with black tunica albuginea. One mature female had lost the right rear foot. All contained food (unrecognizable insects) in the stomachs. All specimens were found along the river; one (LSUS 4867) was under a rock in the river at 1820 h on 14 July. The mid-dorsal stripes were tan (LSUS 4871–72) or yellow (LSUS 4868).

Rana angolensis Bocage.—(LSUS 4812; B). A female (SVL = 77) containing large, pigmented, ovarian eggs and an enlarged oviduct, was found on 15 July. The stomach contained insects.

Phrynobatrachus mababiensis Fitz-Simons.—(LSUS 4866, 4874–75; A). This is the first report of this taxon as a distinct species in Kenya. Duff-MacKay (1980) reported *mababiensis* as a subspecies of *P. ukingensis*. Two females (4866, 4875; SVL = 17.3, 17.6, respectively) and one male (SVL = 14.8) were found. Ovarian eggs were enlarged (1.0, 0.8, respectively) and pigmented. The testis of the male was 0.9 × 1.7. All contained food in the stomachs. These specimens were caught on 29 July from beneath rocks in wet sand along the edge of the water between 1605–1650 h.

Chamaeleo gracilis Hallowell.—(LSUS 4951; C). A male (SVL = 100, tail = 80, tail/total length = 0.44; black testis, 6.3 × 4.4) was found on a small bush near a house, 25 July. The stomach was packed with insects. No others were found after thorough searches in the area. Local residents reported that this species was common at this time of the year.

Hemidactylus brookii Gray.—(LSUS 4893–94; A). A female (4893; SVL = 49), found on 12 July, contained ova 1.0 or smaller in diameter; a male (SVL = 45) captured on 20 July had an unusually fat tail and the right testis was 1.8 × 4.2. Both contained food in the stomachs.

Hemidactylus mabouia (Moreau de Jonnés).—(LSUS 4891–92; A). A female (4891; SVL = 75; ova to 2.0) was found on 19 July at 2320–2350 h and a male (4892; SVL = 48; testis 1.6 × 3.2) on 20 July (air temperature 20.2°C at 2153 and at 2253 h). Both were found on *Acacia* trees at night with food in the stomachs. Both had incomplete tails.

Lygodactylus picturatus Peters.—(LSUS 4895–99, A; n = 5). In one female (LSUS 4895; SVL = 34) the tip of the tail was spatulate in shape with five pairs of ventral lamellae, which had the same appearance as the subdigital lamellae. She had two oviductal eggs (5 × 7). The other specimens had normal tails. Two specimens (4897–8) contained ova up to 3.1 and 1.1 in diameter, respectively. Two males (4896, 4899) had testes 1.1 × 2.6 and 1.6 × 2.4, respectively. The vas deferens of one (4896) was greatly

enlarged. Three specimens contained insects in the stomachs. The gravid female contained unidentifiable debris in the large intestine and one male contained insect remains only in the small intestine. Three specimens (4895, 4896, 4898; 13, 14, and 20 July, respectively) had yellow midventral stripes and the yellow extended onto the venter of each leg in 4895. On LSUS 4896 the yellow was restricted to a median ventral stripe, the throat and chin were black, and the sides of the throat and chest had black streaks; this gecko was found on a tree trunk at 1400 h. Three females (SVL $\bar{X}$ = 34.0, range = 33–50) had black streaks on the chins and two males (SVL = 34, 35) had solid black chins. One female had a complete tail (tail/total length = 0.47). The males had 7 and 9 preanal pores.

Agama agama (Linnaeus).—(LSUS 4930–48, A; 4949, D; 4950, E). Three females under 100 SVL were not reproductive; two larger females contained shelled oviductal eggs (SVL = 103) and ova to 2.4 (SVL = 110). The testes in 11 males under 100 SVL were less than 2.0 × 2.0; four males over 100 SVL ($\bar{X}$ = 119) had testes 3.3–6.0 × 4.3–6.1. SVL for males was $\bar{X}$ = 71.9 (range = 35–142, n = 15) and for females 73.2 (range = 33–110, n = 6). The yolk-sac scar was evident on one female (SVL = 33) and one male (SVL = 35). All contained food. Two juveniles (4931–32; 12 July) had four red dorsal stripes; two adult males (4933–34; 13 July) had four orange dorsal stripes, green spots on the head, and a pale yellow throat. A female (4935) and two males (4936–37) caught at night (2200–2300 h; 13 July) in a crack of a large dead tree had red heads, blue chests, yellowish-brown necks, and bluish-green tails. Another male (4944; 21 July) had a red throat with pink longitudinal stripes, blue venter, and golden-brown neck. Four specimens (4939–42) were found under one rock near the river at 2200 h (20 July). This diurnal species was found at night under bark of dead trees, in cracks in trees and rocks, and under large rocks; none was seen in small mammal burrows. All were extremely wary and took refuge at the slightest disturbance.

Agama rueppelli Vaillant.—(LSUS 4924–28, A; 4929, E). All six specimens were found during 20–28 July (SVL $\bar{X}$ = 70.5, range = 38–88; tail $\bar{X}$ = 163.0, range = 157–169, n = 3; tail/total length $\bar{X}$ = 0.67, range = 0.66–0.67). Ova of three females were 0.6 (SVL = 52), 1.6 (83), and 4.7 (88); testes of three males were 1.1 × 1.7 (38), 5.7 × 7.7 (81), and 6.1 × 9.5 (81). All had food in the stomachs. One female (4925) had a pair of dark, brownish-black chest spots, yellow chin, grayish-tan middorsal stipe, yellow nuchal sides, and a pale pink loreal region. A male (4926) was similar, except paler, and the back of the head was pink. Both specimens were found in the shade of shrubs in the desert away from the river (1200–1230 h). In contrast to *A. agama,* individuals of this species were docile and easily caught.

Eremias spekii Günther.—(LSUS 4907–23; A). SVL was 31–48 ($\bar{X}$ = 39.3, n = 11) in males and 33–53 ($\bar{X}$ = 46.7, n = 6) in females. Four males less than 38 SVL had small testes (1.3 × 1.9), whereas five others with SVLs greater than 40 ($\bar{X}$ = 46) had testes 2.1 × 3.0 or larger; the two largest specimens (48 SVL) had greatly enlarged vas deferentia. Four females had ova 2.2 or smaller; one (4921) had an SVL of 53 and ova as large as 4.6. Males probably reach sexual maturity at approximately 45 SVL and females at approximately 53. All 17 specimens were found in the desert away from the river and contained food in the stomachs, except one female (SVL = 51) that had food only in the large intestine. One female (4907; 12 July), active under a bush in the morning, had a yellowish-orange subcaudal surface changing to yellowish-green at the base of the tail. Two (4908–9) were active between 0830–0900 h. Most were found among low grayish-green shrubs (*Acacia* sp.) in low foothills above the river valley before noon on 20 July. This area was less grazed by goats than the area bor-

dering the river. Lizards escaped into rodent burrows, but apparently stayed just inside the entrance; many were easily dug out by suddenly scooping all of the sand from just behind the burrow entrance into an open area.

Latastia longicaudata (Reuss).—(LSUS 4900–06, A). SVL $\bar{X}$ = 68.0, range = 44–79; tail $\bar{X}$ = 148.3, range = 117–191 (3 females); tail/total length $\bar{X}$ = 0.73, range = 0.72–0.73 (3 females). The male had a long regenerated tail that was 71 percent of its total length. Six females contained ova 0.8–1.8 diameter and the single male (4906; SVL = 79) contained a testis 1.7 × 3.1. All had food in their stomachs. One female (4900) was found under a small bush about 1600 h, 14 July. Six other specimens were found on 20 July at the same time and in the same habitat as that described for *Eremias spekii.*

Lygosoma sundevallii (Smith).—(LSUS 4889–90; A). An adult male (4890; SVL = 79, tail = 58, tail/total length = 0.42) was in a hollow log brought to camp for firewood on 26 July. This male had a testis 2.6 × 7.0 and enlarged vas deferens and contained a 20 mm insect larva. A small female (4889; SVL = 47, tail = 27, tail/total length = 0.36) with ova to 0.6 and several food items in the duodenum was dug out of the sand in the morning of 20 July by digging in loose sand at the bases of small bushes; food items in the intestine suggest that it may not have been foraging that day.

Mabuya quinquetaeniata (Lichtenstein).—(LSUS 4877, A; 4878–84, C; 4885, E). SVL $\bar{X}$ = 68.7, range = 44–89, n = 9; tail $\bar{X}$ = 100.4, range = 70–132, n = 5; tail/total length $\bar{X}$ = 0.60, range = 0.58–0.61, n = 5. Maximum ova size for three females was 1.7; maximum testis size for six males was 1.6 × 2.9. All contained food in the stomachs. One specimen (4877; 18 July) was found on the NW slope of a rocky hill W of camp; several others were extremely wary. On 19 July, seven specimens were collected from a dark lava flow along a dry creek bed. All were captured by stunning with large rubber bands. Their skins were fragile and all were damaged during capture.

Mabuya planifrons (Peters).—(LSUS 4886, C; 4887–88, A; 4952, B). SVL was 93, 104 for the two mature males (4886, 4888; testes 7.8 × 5.0 and 11.6 × 5.0, respectively) and 116 for the single mature female; tail was 130, 119, 221, 156+, respectively. The female contained oviductal ova up to 11.0 diameter. All specimens had arthropod remains in the stomachs. One large adult female (4952) was in thick bermuda grass of a large wet meadow (approximately 0.8 × 0.3 km) on 14 July, at 1000 h. The Loborua River flows through the meadow but was reduced to a meter or so in width by 25 July. This female was pale yellow around the ear openings. A male (4886; 19 July) was caught with *M. quinquetaeniata* on the lava flow. Two others (4887–88) were caught on 21 July; one of these, a juvenile male (4887) with testis 1.5 × 3.0, had a yellowish wash on the lips and soles of the feet.

Discussion

This sample represents a small proportion of the total herpetofauna (more than 340 species) in Kenya. However, it probably represents many of the species of frogs and lizards that normally are active during the dry season in the Isiolo area. Since significant migration is not a documented response for terrestrial amphibians and reptiles, means of individual survival during seasonal drought include dormancy, change in diet, change in microhabitat use, or no change. One of the frogs, *Hemisus marmoratum,* appeared to be in a state of dormancy, but the other species were active and foraging regularly (Table 2). Without comparable study during the rainy season, it is unknown if any of these species undergo seasonal shifts in diet, microhabitat use, or activity. Interspecific competition is assumed to occur among some species of this herpetofauna and is presumably different in the wet and dry seasons. Hebrard & Madsen

Table 2.—Seasonal activity and reproductive condition of 7 species of amphibians (above line) and 11 species of reptiles from the vicinity of the Engare Ondare River, Isiolo District, Kenya. Feeding activity is measured as the percent of stomachs containing recognizable food.

Species	*n*	Percent stomachs with food	Active	Reproductive	Most reliable reproductive condition
Bufo garmani	34	94	Yes	Yes	Oviductal eggs; amplexus observed
Ptychadena mascareniensis	7	100	Yes	Yes	Oviductal eggs
Tomopterna cryptotis	2	50	Yes	No	Testis to 1.0 × 4.5
Ptychadena anchietae	52	92	Yes	No	Calling; pigmented ovarian eggs
Rana angolensis	1	100	Yes	No	Pigmented ovarian eggs
Phrynobatrachus mababiensis	3	100	Yes	No	Pigmented ovarian eggs
Hemisus marmoratum	1	0	No	No	Testis 1.7
Lygodactylus picturatus	5	60	Yes	Yes	Oviductal eggs
Agama agama	21	100	Yes	Yes	Oviductal eggs
Mabuya planifrons	4	100	Yes	Yes	Oviductal eggs
Chamaeleo gracilis	1	100	Yes	No	Testis 4.4 × 6.3
Hemidactylus brookii	2	100	Yes	No	Testis 1.8 × 4.2; ova to 1.0
Hemidactylus mabouia	2	100	Yes	No	Testis 1.6 × 3.2; ova to 2.0
Agama rueppelli	6	100	Yes	No	Testis to 6.1 × 9.5; ova to 4.7
Eremias spekii	17	94	Yes	No	Testis to 2.8 × 4.1; ova to 4.6
Latastia longicaudata	7	100	Yes	No	Testis 1.7 × 3.1; ova to 1.8
Lygosoma sundevallii	2	50	Yes	No	Testis 2.6 × 7.0; ova to 0.6
Mabuya quinquetaeniata	9	100	Yes	No	Testis to 1.6 × 2.9; ova to 1.7

(1984) related differential microhabitat distribution in *Chamaeleo dilepis* in Kenya to environmental stresses imposed on the population during the dry season. During the wet season microhabitat diversity increases due to increased water availability and increased plant diversity (activity); thus, relative interspecific competition probably increases during the dry season owing to a concentration of species in available microhabitat and using reduced food resources (see also Hebrard & Madsen 1984). Garcia & Drummond (1988) found *Thamnophis eques* to be more euryphagous when allopatric with congeners and more stenophagous when sympatric with congeners. Toft & Duellman (1979) suggested that the utilization of reproductive resources is affected by seasonality. Hebrard & Madsen (1984) found that niche expansions by *Chamaeleo* is permitted by the absence of competing species. During the dry season, microhabitat diversity is at a minimum due to water shortage (restricted to the flowing river) and decreased botanical structural complexity (loss of leaves, fewer flowers and fruits, and restricted vegetative growth); however, relative interspecific competition might continue to be high because the fewer active species compete for highly reduced resources (most plants are not growing and flowering to produce suitable microhabitat and food supply). Jenssen (1973) recorded niche shifts in tropical lizards (*Anolis*) due to competition.

Tropical snakes (Henderson et al. 1978) and arboreal frogs (Toft & Duellman 1979) are probably most adversely affected by seasonal drought and, therefore, rely on dormancy to survive the dry period. More terrestrial frogs (less exposed to lowered relative humidity; i.e., *Ptychadena, Rana, Tomopterna,* and *Phrynobatrachus*) probably change diet or microhabitat utilization.

Adaptations to the dry season include dormancy by some species and normal activity by others. Active species have greater relative energy demands and are feeding

whereas those unable to sustain activity (due to inadequate food or water) are dormant during the dry season. Thus, three activity categories for amphibians and reptiles can be recognized during the dry season: 1) active and reproductive, 2) active, but not reproductive, and 3) dormant.

Of the active amphibians encountered in this study, only *Bufo garmani* and *Ptychadena mascareniensis* were reproductive (Table 2); however, all of the other active species had pigmented ovarian eggs or enlarged testes. All of the active frogs that were not reproductive were probably approaching reproduction and would have reproduced when the summer rains began. *Hemisus* is in category three.

Both species of *Hemidactylus* were not reproductive, but *Lygodactylus* was ready for oviposition (Table 2). *Agama agama* was reproductive, but *A. rueppelli* was not. *Mabuya quinquetaeniata* was not reproductive (gonads tiny, apparently regressed), but *M. planifrons* was ready for oviposition (Table 2). For some pairs of species in a genus (*Ptychadena, Agama, Mabuya*) one species is reproductive and the other is not. The nonreproductive condition of several species of amphibians and reptiles and the reproductive condition of others suggest an adaptive partitioning of the reproductive season by congeners, which would result in reduction of demands on the associated resources, and potentially would reduce competition.

Acknowledgments

I thank Mrs. Mwongo (Office of the President, Kenya), Dr. Olinde (Director, Department of Wildlife, Kenya), and Dr. M. Buvi (Assistant Director, Department of Wildlife, Kenya) for the research permit and exportation permits for Kenya. I also thank Dr. Richard Leakey and Mr. Alex Duff-MacKay (National Museum of Kenya) for assistance during the process of obtaining the research permit. For help with collecting I thank James, Shadrack, Raoul, Konoso, and Charlie. Vaughn Langman (LSUS) waived a portion of the commercial camp fee during the stay in his camp. I am most indebted to John L. Darling for his untiring assistance and perseverance during this expedition. For permission to examine specimens in their care I thank Dr. Barry Clarke, British Museum (Natural History) (BM), and Dr. W. Ronald Heyer, U.S. National Museum of Natural History (USNM). I thank LSU in Shreveport for a faculty research grant (no. 757-05-6002) for partial support of this project.

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